VI. Appendix A: Legislative and Regulatory Background

What is Section 706?

The following is the text of Section 706 from the *Telecommunications Act of 1996*:

SEC. 706. ADVANCED TELECOMMUNICATIONS INCENTIVES.

(a) IN GENERAL- The Commission and each State commission with regulatory jurisdiction over telecommunications services shall encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans (including, in particular, elementary and secondary schools and classrooms) by utilizing, in a manner consistent with the public interest, convenience, and necessity, price cap regulation, regulatory forbearance, measures that promote competition in the local telecommunications market, or other regulating methods that remove barriers to infrastructure investment.

(b) INQUIRY- The Commission shall, within 30 months after the date of enactment of this Act, and regularly thereafter, initiate a notice of inquiry concerning the availability of advanced telecommunications capability to all Americans (including, in particular, elementary and secondary schools and classrooms) and shall complete the inquiry within 180 days after its initiation. In the inquiry, the Commission shall determine whether advanced telecommunications capability is being deployed to all Americans in a reasonable and timely fashion. If the Commission's determination is negative, it shall take immediate action to accelerate deployment of such capability by removing barriers to infrastructure investment and by promoting competition in the telecommunications market.

(c) DEFINITIONS- For purposes of this subsection:

1. ADVANCED TELECOMMUNICATIONS CAPABILITY- The term 'advanced telecommunications capability' is defined, without regard to any transmission media or technology, as high-speed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology.

2. ELEMENTARY AND SECONDARY SCHOOLS- The term 'elementary and secondary schools' means elementary and secondary schools, as defined in paragraphs (14) and (25), respectively, of section 14101 of the *Elementary and Secondary Education Act of 1965* (20 U.S.C. 8801).

Is there additional regulatory background?

The FCC has a *Notice of Inquiry* to examine:

> the effect of its rules on the testing of new technologies by regulated companies and the ways in which its rules may be changed to encourage and facilitate such tests. The Commission noted that experiments involving new technology, including technical trials and market trials, are a critical step in the process of introducing new services that benefit the public. Allowing companies to conduct experiments without unnecessary regulatory burdens is essential to this end.[22]

In the proceeding, the FCC asks whether it:

> can apply its section 11 deregulatory and streamlining mandate to remove or restructure existing regulations in order to promote technology testing.[23]

Alternatively, the FCC asks whether it:

> should and can use our new forbearance authority to accomplish the same goal. New section 10 of the *Act of 1996* requires the Commission to forbear from applying sections of the *Act* and its regulations to carriers and services upon satisfying a stated three-part test.[24]

This proceeding then talks about regulatory lag leading to the "delay in the delivery to customers of services that employ new technology, or new applications of existing technology that stretch or fall outside existing regulatory paradigms."[25] The FCC then provides the historical examples of microwave technology and cellular telephone service.

VII. Appendix B: Additional Technical Background

How are data packets from multiple sources sent?

A technique to maximize transport facilities is to combine data packets from multiple sources into a single transport facility or pipe. This process is called multiplexing. Placing all the data packets into a single transmission path improves the efficiency of the single transmission path and eliminates the need for dedicated facilities for each computer.

How is data sent over a voice-grade circuit?

Today's telephone network has been designed to provide high-quality voice communications. The design criteria were developed during a time when the primary considerations were to provide connections or systems that optimized voice communications. Most voice frequencies fall within the range of 300 hertz (Hz) to 3000 Hz. Signal transmission in this band allows voice reproduction to be understandable and intelligible.

When digital data from a computer is transmitted over voice circuits, modems are used to provide computer-to-computer connections. The actual data speed that can be supported over a two-wire voice circuit is a function of bandwidth, loss, and noise. Many computer and modem manufacturers claim to be able to provide data speeds at a level of 56 kilobits per second (kbps). However, these speeds are based on perfect settings, such as in the laboratory. Factors that limit modem speed are related to the characteristics of the physical voice loop and include the following:

- Distance from the local telephone company switch and the customer's location
- Type of material used in the local loop (copper wire, coaxial, fiber, etc.)
- Loading schemes: boost signal strength over a loop and filter the analog signal (which limits data speeds of modems)
- Condition of the wire connections
- Insulation on the wires
- Condition of the wires at the customer's location (inside wiring)

When all the conditions of the customer's voice-circuit loop are taken into account, it may not perform or it may send data at much lower speeds. The result in such cases is that data transmission may occur at an extremely slow rate or may not occur at all. Most modems have the capability of adjusting speeds to conditions and will operate at lower speeds such as 300, 1200, 2400, 4800, 9600, 14400, or 33600 bits per second. With xDSL technologies, data transmission speeds over the local loop are expanded.

VII. Appendix B: Additional Technical Background, cont.

What is Internet Protocol (IP) telephony?

Voice over a packet-switched network involves a process of converting the analog voice into digits and then carving this stream of binary digits into groups, called packets. This process produces what is called "packetized" voice. Packets contain information in a specific format that consists of the information (data in bytes, also called the "payload") and routing information in a header (includes the origin of the packet, the destination of the packet, the length or size of the packet, and maintenance information). Packetized voice in a transmission channel is also know as IP telephony.

Packets for data work extremely well since the information is digital at its origin. However, voice is sensitive to small delays or incomplete harmonics and the process of converting the voice signal to digits combined with packetizing of these digits creates the potential for distortion.

What is latency in packet transmission? How is this related to IP telephony?

"Latency" is defined as the amount of time it takes to get information through a network. In a digital transmission environment, voice communications are converted from analog to digital format. In this conversion process, spoken words require many digital packets to transmit the complete sentence. As these data packets traverse the networks, packets can be lost and retransmitted, can be received in a different order than was sent, and can take multiple network routes to a destination point.

When the digital packets reach their destination they are placed into the proper order, and converted back to voice. At this time, several imperfections may be noticed because of the latency. Some words may be incomplete, out of order, or garbled. The participants in the communication link may also notice dead spots (intervals with no sound) or may notice delays in response times between the parties.

As technology advances, such as the deployment of more robust networks and packet switches that prioritize voice packets, the overall quality of voice communications over the Internet will improve.

VII. Appendix B: Additional Technical Background, cont.

The Family of Various Digital Subscriber Line (xDSL) Technologies:

What Type of DSL Technology?	What is the Speed (Bandwidth/ Data Rate)?	What are the Loop Requirements? (1 Loop = 2 pair of copper wires)	What is it?
ADSL Asymmetric Digital Subscriber Line	Downstream: 786 kbps to 9 mpbs Upstream: 128 kbps to 1.5 mbps	1 Loop Limit of 16,000 feet to 18,000 feet	A 1990s technology that was originally envisioned to provide video on demand, ADSL is being developed to combine voice and data services on the same loop. The "asymmetric" refers to the difference in upstream and downstream data rates. These match 1998 Internet use patterns — mouse clicks upstream and lots of information downstream.
HDSL High Bit Rate Digital Subscriber Line	1.5 mbps	2 Loops Limit of 12,000 feet	1980s technology developed to extend the length of a T1 line (broadband channel).
IDSL "ISDN" Digital Subscriber Line	144 kpbs	1 Loop No limit on loop length	1997 technology developed to expand standard ISDN customer equipment. An unswitched, data-only service that does not support voice calls.
RADSL Rate Adaptive Digital Subscriber Line	The data rate is adjustable	1 Loop Limit of 16,000 feet	A version of ADSL technology where the modem tests the loop at the start of the connection and adapts for the fastest speed that the line can handle.
SDSL Symmetric or Single Line Digital Subscriber Line	0.75 mbps	1 Loop Limit of 12,000 feet	A half-speed version of HDSL technology. Allows data and voice over a single loop.
VDSL Very High Rate Digital Subscriber Line	12.9 mbps to 52.8 mbps	1 Loop Limit ranges from 1,000 to 4,500 feet	A 1998 technology designed to provide fiber technology to households (fiber to the curb) or fiber to a copper wire interface of up to approximately 3,000 feet from the household. Greatest speed and bandwidth of all the DSL technologies. May be used for data, voice, and video.

Sources: Project participants and United States Telephone Association (USTA), "An Overview of xDSL Technologies," Technical Information Document, March 17, 1998.

VIII. Notes

Notes

1. Telecommunications Act of 1996, Pub. L. No. 104-104, Stat.56 [hereinafter referred to as the *Act of 1996*], codified at 47 U.S. C. §§ 151 et seq., Section 706(b). See **Section VI, Appendix A,** for the text of Section 706.

2. *Ibid.* The *Act of 1996* requires the FCC to initiate an inquiry "within 30 months after the date of enactment of this Act" and to complete this inquiry 180 days later.

3. Conversions to a digital format may also occur at a neighborhood node where copper wire technology interconnects to digital fiber technology.

4. For an explanation of peering arrangements, see **Section III, How do ISPs connect to the Internet?**

5. How does a modem work? When data is transmitted over voice circuits, modems are used to provide computer-to-computer connections. A modem, which is a Modulator/DEModulator, is a piece of equipment that converts digital signals to analog signals and vice-versa. Modems are used to send data signals (digital) over the traditional telephone network (the PSTN), which is generally analog.

   A modem modulates the "1's" and "O's", or "ons" and "offs", of digital data into tones that can be carried by the telephone network. When digital data is transmitted between two computers over voice-grade circuits, a modem is required at each end of the connection.

   Access to the Internet over voice circuits requires two modems, one at the customer's location and another at the ISP location. The modems at the ISP are located prior to the Internet gateway and are normally provided in sufficient numbers to accommodate the needs of their clientele. An ISP will have a number of modems to accommodate the traffic connected to the PSTN. Grouped together, these ISP modems are referred to as a "modem bank."

6. There are virtual private lines, where there is no permanent physical connection but the service functions as if there were one.

7. A set top box is located at the customer TV set and may perform several functions. If the TV set is not "cable ready", this set top box can act as a "tuner", or TV channel selector, for the analog television signals. In digital cable TV systems, the set top box also acts as a demodulator and channel selector of digital TV channels.

8. A cable modem is different from the analog-digital modem that connects the computer to a telephone line. In addition to the channels used for video services, the cable modem divides the bandwidth on the coaxial cable for data into two paths: one for sending and one for receiving. It is necessary to have cable modem termination equipment at the cable TV company's head end.

9. For a description of how data packets are sent, see **Section VII, Appendix B.**

10. Network technologies evolve over time. The process is gradual, with older technologies and standards co-existing with newer ones. For example, the early telephone switches were completely mechanical with operators literally linking one line to another with a piece of wire. Since then switching technologies evolved from mechanical switches to electrical switches to digital switches. At the same time the transmission standards have also evolved from analog to digital. Similarly, there are both cellular and personal communications services (PCS) that both allow customer mobility for voice calls. However, cellular is the older technology of the two and is currently evolving from analog to digital transmissions.

11. Unless the copper pair is engineered to handle higher bandwidth.

12. For a description of multiplexing, see **Section VI, Appendix A, How are data packets sent from multiple sources?**

13. ATM uses a 53-byte cell, or packet, for transferring data.

14. The optical carrier (OC) rates (which are OC-3, OC-12, OC-48, and OC-192) use a base rate of 51.84 mbps or the OC-1 rate. The OC-3 rate could be determined by taking the 51.84 mbps base rate times 3 to equal 155 mbps (or N times 51.84 mbps equals the bit rate).

15. SONET standards allow the inter-working of transmission products from multiple users.

16. SONET technology is capable of back-to-back multiplexing, has digital cross-connect panels, and easy access to low-speed signals such as DS-0 and DS-1 without multi-stage multiplexing and de-multiplexing.

17. Find/SVP, *The American Internet User Survey: New Survey Highlights*, at http://etrg.findsvp.com/features/newinet.html, April 5 1996. For background information, see Carol Weinhaus, Bob Lock, John Bosley, et al., *A Snapshot in Time: LEC Switch Investment and Price Structures for Connections to the Switch Just before the Telecommunications Act of 1996*, Presentation at the July 1996 NARUC Meeting, Los Angeles, CA, May 10, 1996, Figure 4, page 12.

18. Roger L. Freeman, "Bits, Symbols, Bands, and Bandwidth," *IEEE Communication*, April 1998, page 9.

19. In practice, bit rates of more than double the bandwidth are achievable.

20. Typically, a broadband facility is divided into "channels" that operate at pre-defined frequencies. "Guardbands" are also used within the broad range of frequencies to separate the channels and provide assurance against the overlapping of channels.

21. Robert K. Heldman, T.F. Madison, and T.A. Bystrzycki, *Future Telecommunications: Information Applications, Services, & Infrastructure*, McGraw-Hill, Inc., Washington, DC, 1993, page 23.

22. FCC, "FCC Launches Proceeding to Promote Testing of New Technologies," *FCC News*, Report No. CC 98-16, June 11, 1998. FCC website: http://www.fcc.gov/Bureaus/Common_Carrier/News_Releases/1998/nrcc8042.html. See also FCC, *In the Matter of 1998 Biennial Regulatory Review — Testing New Technology* [hereinafter referred to a *TNT Proceeding*], CC Docket No. 98-98, *Notice of Inquiry*, FCC 98-118, June 11, 1998

23. *TNT Proceeding*, ¶ 3, pages 2 and 3.

24. *Ibid.*, ¶ 3, pages 2 and 3.

25. *Ibid.*, ¶ 5, pages 3 and 4.